# Associations between chewing lice (Insecta, Phthiraptera) and albatrosses and petrels (Aves, Procellariiformes) collected in Brazil

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ABSTRACT. Chewing lice were searched on 197 skins of 28 species of procellariiform birds collected in Brazil. A total of 38 species of lice were found on 112 skins belonging to 22 bird species. The lice were slide-mounted and identified. A list of lice species found and their host species is given and some host-louse associations are discussed under an evolutionary perspective.
KEY WORDS. Amblycera; ectoparasites; host-parasite relationship; Ischnocera.

RESUMO. **Associações entre malófagos (Insecta, Phthiraptera) e albatrozes e petréis (Aves, Procellariiformes) capturados no Brasil.** Malófagos foram procurados em 197 peles de 28 espécies de aves Procellariiformes capturadas no Brasil. Um total de 38 espécies de piolhos foram encontradas em 112 peles pertencentes a 22 espécies de aves. Os piolhos foram montados em lâminas e identificados. Uma lista com as espécies de piolhos encontradas e seus hospedeiros é dada, além de algumas associações entre os piolhos e as aves serem discutidas sob uma perspectiva evolutiva.
PALAVRAS-CHAVE. Amblycera; ectoparasitos; Ischnocera; relação parasito-hospedeiro.

Albatrosses and petrels are primarily oceanic birds, representing almost the half of the bird biodiversity of the world oceans, a habitat where the avifaunal diversity is considerably reduced if compared with terrestrial habitats. Procellariiform biology and behaviour are unique among birds, as is their ectoparasitic fauna. Among the latter, feather mites and feather lice are the most abundant in numbers of species and of individuals (Price *et al*. 2003).

Chewing lice are wingless, dorso-ventrally flattened insects with chewing mouth parts, highly specialized to live on avian and mammalian hosts as permanent and obligate ectoparasites (Johnson & Clayton 2003). Among all other ectoparasites, lice are the most host specific (Smith 2001). Birds are parasitized by louse species belonging to two (Amblycera and Ischnocera) of the four suborders forming the insect order Phthiraptera.

The first two species of chewing lice from Procellariiformes were described by Fabricius (1775: 808) from a petrel and an albatross collected off the coast of Brazil by Joseph Banks, during Captain James Cook's first voyage around the world (Palma 1991). One was "*Pediculus Procellariae*" [= *Halipeurus procellariae* (Fabricius, 1775)] from a "Brasiliae procellariis" and the other was "*Pediculus Diomedeae*" [= *Paraclisis diomedeae* (Fabricius, 1775)] from a "Brasiliae diomedeis". As many as 126 other louse species, still considered valid today, were described from albatrosses and petrels since 1775.

Most of our knowledge about Brazilian bird lice is based on the work of Lindolpho Rocha Guimarães (1908-1998) who published many papers between 1936 and 1985. Guimarães published the original descriptions of 84 species of lice, with 73 of them still recognised as valid, a figure that earned him the 15th place among the most productive phthirapterists in the world (Price *et al*. 2003). However, most of Guimarães work was on lice of terrestrial birds. Recently, some papers on the ecology and host relationships of Brazilian lice have been published (Oniki 1990, Roda & Farias 1999, Freitas *et al*. 2002, Neves *et al*. 2000) but, again, they deal with terrestrial hosts only.

The 128 louse species of procellariiform birds are distributed over 117 host species, with one of the greatest ratios (430) of louse-host associations found among chewing lice (Price *et al*. 2003). All the louse species living on albatrosses and petrels are at present placed in a total of 16 genera, with 14 of these being exclusive to the Procellariiformes. Many authors described lice from Procellariiformes in an *ad hoc* fashion, until Thompson (1938, 1939a, 1940) published the first papers dealing exclusively with these lice. Since then, many revisions have been produced, usually covering one genus each, and a complete overview of all procellariiform lice was published by Timmermann (1965). Useful generic revisions have been published dealing with the following genera in the family Philopteridae (suborder Ischnocera): *Trabeculus* Rudow and *Docophoroides* Giglioli

by Timmermann (1959a, b); *Halipeurus* Thompson by Edwards (1961) and by Timmermann (1960, 1961b); *Pseudonirmus* Mjöberg, *Episbates* Thompson and *Philoceanus* Kellogg by Timmermann (1961a, c); *Bedfordiella* Thompson, *Harrisoniella* Bedford, *Perineus* Thompson and *Naubates* Bedford by Palma & Pilgrim (1983, 1984, 1988, 2002); *Saemundssonia* (*Puffinoecus*) by Martin-Mateo (1996). Clay (1940) revised all the species which at present are placed in the genus *Paraclisis* Timmermann, but which were included in *Perineus* at that time. Among the Menoponidae (suborder Amblycera), the genera *Austromenopon* Bedford and *Longimenopon* Thompson have been revised by Price & Clay (1972) and by Timmermann (1957), respectively. Price *et al*. (2003) published the most recent and comprehensive checklist of bird chewing lice with their host associations.

The purpose of this paper is to contribute to the knowledge of feather lice found on species of procellariiform birds in Brazil and to discuss some of the evolutionary implications of the host-louse associations under a phylogenetic perspective.

## MATERIAL AND METHODS

Lice were collected from 112 bird skins (57%) belonging to 22 species, from a total of 197 skins examined belonging to 28 species of Procellariiformes from Brazil, and deposited in the Ornithological collection of the Museu Nacional, Universidade Federal do Rio de Janeiro. The bird species studied with louse-negative results were: *Diomedea exulans* Linnaeus, 1758 [Diomedeidae]; *Aphrodroma brevirostris* (Lesson, 1831); *Pterodroma lessonii* (Garnot, 1826); *Procellaria cinerea* Gmelin, 1789; *Puffinus assimilis* Gould, 1838 [Procellariidae] and *Oceanodroma castro* (Harcourt, 1851) [Hydrobatidae].

The collecting technique used was that published by Hopkins (1949). After their removal from the skins, lice were slide-mounted following the technique of Palma (1978). Some samples were not identified to species because of the absence of one of the sexes, or the lack of adult lice. We regard as stragglers those lice which have changed hosts by natural means, while contaminants are lice which have been transferred from one host species to another by human agency (Pilgrim & Palma 1982). Louse nomenclature follows that used by Price *et al*. (2003) and the bird names follow Remsen *et al*. (2004). The evolutionary inferences are based on the phylogeny proposed by Penhallurick & Wink (2004).

## RESULTS

A total of 33 species of lice were identified, with a further 5 records left at the genus level (species under study), totalizing 38 species.

The lice species recorded were distributed in two suborders and two families. The suborder Amblycera Kellogg is represented by the family Menoponidae Mjöberg and species: *Ancistrona vagelli* (Fabricius, 1787); *Austromenopon brevifimbriatum* (Piaget, 1880); *A. echinatum* Edwards, 1960; *A. edwardsi* Price & Clay, 1972; *A. navigans* (Kellogg, 1896); *A. ossifragae* (Eichler, 1949); *A. paululum* (Kellogg & Chapman, 1899); *A. popellus* (Piaget, 1890); *A. stammeri* Timmermann, 1959; *Austromenopon* sp.; and *Longimenopon galeatum* Timmermann, 1957.

The species of the suborder Ischnocera Kellogg, family Philopteridae Burmeister were: *Docophoroides brevis* (Dufour, 1835); *D. harrisoni* Waterston, 1917; *D. murphyi* (Kellogg, 1914); *D. simplex* (Waterston, 1914); *Halipeurus* (*Halipeurus*) *abnormis* (Piaget, 1885); *H.* (*Halipeurus*) *diversus* (Kellogg, 1896); *H.* (*Halipeurus*) *procellariae*; *H.* (*Halipeurus*) *turtur* Edwards, 1961; *H.* (*Synnautes*) *pelagicus* (Denny, 1842); *Naubates* (*Naubates*) *fuliginosus* (Taschenberg, 1882); *N.* (*Guenterion*) *prioni* (Enderlein, 1909); *Naubates* sp.; *Paraclisis diomedeae*; *P. obscura* (Rudow, 1869); *Philoceanus fasciatus* (Carriker, 1958); *P. robertsi* (Clay, 1940); *Pseudonirmus gurlti* (Taschenberg, 1882); *Saemundssonia* (*Saemundssonia*) *bicolor* (Rudow, 1870); *S.* (*Saemundssonia*) *stammeri* Timmermann, 1959; *S.* (*Saemundssonia*) *desolata* Timmermann, 1959; *S.* (*Puffinoecus*) *peusi* (Eichler, 1949); *Saemundssonia* sp.; *Trabeculus aviator* (Evans, 1912); *T. hexakon* (Waterston, 1914); *T. schillingi* Rudow, 1866; *Trabeculus* sp.

Species of chewing lice and birds found in associations are shown in the table I.

## DISCUSSION

Most of the records and host-louse associations listed in the table I agree with previous studies by Thompson (1939b), Ward & Downey (1973), Pilgrim & Palma (1982), Palma & Horning (2002) and Price *et al*. (2003) for regional and world lists.

On members of the albatross family Diomedeidae, we found the genera *Docophoroides* (three species) and *Paraclisis* (one species), both belonging to the louse family Philopteridae, which corroborate records by Thompson (1939b), Ward & Downey (1973), Pilgrim & Palma (1982), and Palma & Horning (2002). We were not able to find any specimen of the genera *Episbates*, *Harrisoniella* or *Perineus*, which are also characteristic ectoparasites on members of the Diomedeidae (Price *et al*. 2003: 368). Also, on the Diomedeidae, we found one species of the genus *Austromenopon* (Family Menoponidae), the only genus of the suborder Amblycera with species parasitic on albatrosses (Thompson 1939b, Ward & Downey 1973, Pilgrim & Palma 1982, Price *et al.* 2003).

Among petrels and shearwaters (Procellariidae), we found records that agree with those published by Thompson (1939b), Ward & Downey (1973), Pilgrim & Palma (1982), and Palma & Horning (2002). The only philopterid genus not recorded in our work was *Bedfordiella*, a monotypic genus exclusive to the Kerguelen petrel (Palma & Pilgrim 1983). The genera of Menoponidae (Amblycera) found on the Procellariidae also agree with literature records (Pilgrim & Palma 1982, Palma & Horning 2002, Price *et al*. 2003). Our finding of *Longimenopon* is a rare occurrence, because of the special microhabitat occupied by these lice, inside the calamus of primary feathers.

In the family Hydrobatidae (storm petrels), our records also agree with those in Pilgrim & Palma (1982) and Price *et al*.

Table I. The lice species (lines) and the hosts (birds species on columns) found in association. The "X" represents the positive records and the "?" the possible stragglers or contaminants discussed in the text.

| | Chewing lice \ Birds | Diomedeidae | | | | | Procellariidae | | | | | | | | | | | | | | Hydrobatidae | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Diomedea epomophora* Lesson, 1825 | *Thalassarche melanophris* (Temminck, 1828) | *Thalassarche chlororhynchos* (Gmelin, 1789) | *Thalassarche chrysostoma* (Forster, 1785) | *Thalassarche cauta* (Gould, 1841) | *Macronectes giganteus* (Gmelin, 1789) | *Fulmarus glacialoides* (Smith, 1840) | *Daption capense* (Linnaeus, 1758) | *Pterodroma macroptera* (Smith, 1840) | *Pterodroma incerta* (Schlegel, 1863) | *Pterodroma mollis* (Gould, 1844) | *P. arminjoniana* (Giglioli & Salvadori, 1869) | *Pachyptila belcheri* (Mathews, 1912) | *Pachyptila desolata* (Gmelin, 1789) | *Procellaria aequinoctialis* Linnaeus, 1758 | *Calonectris diomedea* (Scopoli, 1769) | *Puffinus gravis* (O'Reilly, 1818) | *Puffinus griseus* (Gmelin, 1789) | *Puffinus puffinus* (Brunnich, 1764) | *Oceanites oceanicus* (Kuhl, 1820) | *Oceanodroma leucorhoa* (Vieillot, 1818) | *Fregetta tropica* (Gould, 1844) |
| Menoponidae | *Ancistrona vagelli* | | | | | | | X | | | | | | | | | | X | | | | | |
| | *Austromenopon brevifimbriatum* | | | | | | | X | | | | | | | | | | | | | | | |
| | *Austromenopon echinatum* | | | | | | | | | | | | | | | | X | | | | | | |
| | *Austromenopon edwardsi* | | | | | | | | | | | | | | | | | | | ? | | | |
| | *Austromenopon navigans* | | X | | | X | | | | | | | | | | | | | | | | | |
| | *Austromenopon ossifragae* | | | | | | X | | | | | | | | | | | | | | | | |
| | *Austromenopon paululum* | | | | | | | | | | | | | | | | | X | | | | | |
| | *Austromenopon popellus* | | | | | | | | | | X | | | | | | | | | | | | |
| | *Austromenopon stammeri* | | | | | | | | | | | | | | X | | | | | | | | |
| | *Austromenopon* sp. | | | | | | | | | | | X | | | | | | | | | | | |
| | *Longimenopon galeatum* | | | | | | | | | | | | | | X | | | | | | | | |
| Philopteridae | *Docophoroides brevis* | X | | | | | | | | | | | | | | | | | | | | | |
| | *Docophoroides harrisoni* | | | | | X | | | | | | | | | | | | | | | | | |
| | *Docophoroides murphyi* | | | | | | X | | | | | | | | | | | | | | | | |
| | *Docophoroides simplex* | | X | | | | | | | | | | | | | | | | | | | | |
| | *Halipeurus abnormis* | | | | | | | | | | | | | | | | X | | | | | | |
| | *Halipeurus diversus* | | | | | | | | | | | | | | | | | | | X | | | |
| | *Halipeurus procellariae* | | | | | | | ? | | X | X | | | | | | | | | | | | |
| | *Halipeurus turtur* | | | ? | | | | | | | | | | | | | | | | | | | |
| | *Halipeurus pelagicus* | | | | | | | | | | | | | | | | | | | | | X | |
| | *Naubates fuliginosus* | | | | | | | | | | | | | | | X | | | | | | | |
| | *Naubates prioni* | | | | | | | | | | | | | X | X | | | | | | | | |
| | *Naubates* sp. | | | | | | | | ? | | X | | X | | | | | | | | | | |
| | *Paraclisis diomedeae* | | X | | | X | | | | | | | | | | | | | | | | | |
| | *Paraclisis obscura* | | | | ? | | X | | | | | | | | | | | | | | | | |
| | *Perineus nigrolimbatus* | | | | | | | X | | | | | | | | | | ? | | | | | |
| | *Philoceanus fasciatus* | | | | | | | | | | | | | | | | | | | | | | X |
| | *Philoceanus robertsi* | | | | | | | | | | | | | | | | | | | | X | | |
| | *Pseudonirmus gurlti* | | | | | | | | X | | | | | | | | | | | | | | |
| | *Saemundssonia bicolor* | | | | | | | X | | | ? | | | | | ? | | ? | | | | | |
| | *Saemundssonia stammeri* | | | | | | | | X | | | | | | | | | | | | | | |
| | *Saemundssonia desolata* | | | | | | | | | | | | | X | X | | | | | | | | |
| | *Saemundssonia peusi* | | | | | | | | | | | | | | | | X | | | | | | |
| | *Saemundssonia* sp. | | | | | | | | | | | X | | | | | | | | | | | |
| | *Trabeculus aviator* | | | | | | | | | | | | | | | | | | | X | | | |
| | *Trabeculus hexakon* | | | | | | | ? | | | | | | | | X | | X | X | | | | |
| | *Trabeculus schillingi* | | | | | | | | | | X | X | | | | | | | | | | | |
| | *Trabeculus* sp. | | | | | | | | | | | | X | | | | | | | | | | |

(2003). Among the skins of Brazilian storm petrels examined, we were unable to find any louse of the genera *Saemundssonia* (Philopteridae), *Austromenopon*, or *Longimenopon* (Menoponidae), all known to include species parasitic on hydrobatid hosts (Price *et al.* 2003).

Some of these associations point clearly to a coevolution of these parasites with various taxa of Procellariiformes, indicating a potential use of louse species in future cladistic analyses of the bird order. At the host subfamily level it can be exemplified by species such as the louse *Austromenopon navigans* and the genus *Docophoroides* that were clearly related to the Diomedeinae, a monophyletic group corroborated by Penhallurick & Wink (2004). At the host genus level, the louse *Trabeculus schillingi* occurs only in *Pterodroma*. The louse genus *Philoceanus* is associated with the family Hydrobatidae only and, in this study, it was found in *Ocenites oceanicus* and *Fregetta tropica*. Some genera, for instance *Saemundssonia* and *Trabeculus*, were found in our study exclusively associated with the Procellariidae. It is worth mentioning that the clade that comprises the Procellariidae, as proposed by Penhallurick & Wink (2004), excludes the genus *Pachyptila*, considered by them as *incertae sedis*. The clade formed by the species of *Pachyptila* hosts the lice *Naubates prioni* and *Saemundssonia desolata*.

On the other hand, a comparison of the distribution of the lice with the procellariform phylogeny shows some interesting aspect on the evolutionary trend of the lice. Species of the genera *Austromenopon*, *Docophoroides* and *Paraclisis* that are parasitic on the Diomedeinae may, after a proper phylogenetic analysis, demonstrate some degree of dispersion in the direction of *Macronectes giganteus* (Procellariidae) that also hosts those louse genera. This phenomenon could point to some degree of convergence in habits or habitat of both bird groups.

A comparison of the distribution of louse species on Procellariiformes with the phylogeny of this order can therefore be used as a more testable criterium to the definition of what can be considered contaminants or stragglers, because both are often expected when lice are collected from bird skins kept in museums. New occurrences of the same parasite in close host species could be treated as possible new records, but they still need to be confirmed by further sampling. Other unexpected new records should be considered as most likely contaminants.

One example of this approach is the record of *Halipeurus* (*Halipeurus*) *turtur* from *Thalassarche chlororhynchos*. It is here regarded as a possible straggler or contaminant, given the high degree of specificity shown by species of the genus *Halipeurus* with the families Procellariidae and Hydrobatidae (Edwards 1961, Price *et al*. 2003), but it is interesting to draw attention to the fact that Penhallurick & Wink (2004) considered the Hydrobatidae and the Procellariidae as polyphyletic groups. This is also the case of our record of *Paraclisis obscura* on *Thalassarche chrysostoma*, given the high degree of host-specificity shown by *P. obscura* with species of *Macronectes* only (Pilgrim & Palma 1982, Price *et al*. 2003).

Other records that could be attributed to contamination or straggling are: *Perineus nigrolimbatus*, (a louse associated with *Fulmarus*) from *Puffinus gravis*, as no species of *Puffinus* is a natural host to any species of *Perineus*, and *Trabeculus hexakon* (a louse species associated with the genera *Procellaria*, *Puffinus* and *Pterodroma*) from *Fulmarus glacialoides*, because no species of *Fulmarus* is a natural host to any species of *Trabeculus*. The natural and regular host species for *Perineus nigrolimbatus* and *Trabeculus hexakon* were taken from Pilgrim & Palma 1982 and Price *et al*. 2003 as shown in the table I.

The record of *Halipeurus (Halipeurus) procellariae* from *Fulmarus glacialoides* was not expected because no species of *Fulmarus* has ever been reported as a natural host to any species of *Halipeurus*. This is clearly a case of straggling or contamination.

Furthermore, the unexpected records of *Saemundssonia bicolor* from *Pterodroma incerta*, *Procellaria aequinoctialis* and *Puffinus gravis* (all based on one specimen) should also be interpreted as stragglers or contaminants (Foster *et al*. 1996, Price *et al*. 2003), although they are all present in the monophyletic Procellariidae of Penhallurick & Wink (2004). *Austromenopon edwardsi* from *Puffinus puffinus* should also be regarded as straggler or contaminant, but it is important to mention that this species has already been found in other species of *Puffinus* (*P. heinrothi* Reichenov, *P. lherminieri* Lesson and *P. navitatis* Streets). The lack of a natural host-louse association between *Saemundssonia bicolor* and *Pterodroma incerta*, *Procellaria aequinoctialis* & *Puffinus gravis* has already been tested and shown to be negative by Palma & Pilgrim (1982), Foster *et al.* (1996), and several other studies.

Many chewing lice cannot be identified to species when only immature stages or one sex of the adult stage is found. In addition, the probability of finding both sexes on museum skins is low because handling and storage practices causes loss of specimens. Therefore, chewing lice on four skin samples could only be identified to the genus level as shown in the table I. These specimens are included in this study because this information contributes to our current knowledge of bird-louse relationships. For example, it was confirmed that louse specimens identified only to genera, and belonging to *Naubates*, *Austromenopon*, *Saemundssonia*, and *Trabeculus*, have an association with the avian family Procellariidae. Other studies (Price *et al*. 2003) have shown that only one species of the four genera mentioned above has been collected on a unique species within the Procellariidae. Therefore, it can be suggested that the unidentified lice specimens are actually *N. damma* Timmermann, 1961 (on *P. arminjoniana*) and *N. pterodromi* Bedford, 1930 (on *P. incerta*), *Austromenpon popellus*, *Saemundssonia enderleini* (Eichler, 1949), and *Trabeculus fuscoclypeatus* (Johnson & Harrison, 1912). However, since we cannot confirm morphologically these specimens to species, we decided to be cautious and merely report them to the level of genera. The finding of *Naubates* sp. in a skin of *Daption capensis* is a true case of contamination.

Museum collections are still a useful source of material when access to live or freshly killed birds is not possible. The host-louse associations presented here will facilitate the addition of future new records of procellariiform lice from field collections, as well as to correct possible errors. This list is by no means complete, as we are well aware that preserved museum skins carry only a fraction of all the lice present on the bird at the time of death. For example, many procellariiform birds are collected dead on beaches, after having been washed by sea waves and deposited on the sand, a process that is known to remove lice from the plumage (Ricardo L. Palma, Museum of New Zealand Te Papa Tongarewa, pers. comm. 2004). Judging from the large number of host-louse associations published for all species of Procellariiformes and the results of this paper, future collecting from albatrosses and petrels in Brazil will produce a great number of additional louse records, thus contributing to the understanding of the evolution of this bird order. A cladistic analysis of the Procellariiformes, based on their lice as characters, will eventually be possible with the increase of knowledge of these host-louse associations.

## ACKNOWLEDGEMENTS

To the Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ) for support to M.A. Raposo (proc. Instalação E-26/ 170.871/2003 and Primeiros Projetos E-26/ 170.642/2004). To Gabriel Mejdalani and Jorge Bruno Nacinovic for their review of the final version, and to Ricardo L. Palma (Curator of Insects, Museum of New Zealand Te Papa Tongarewa, Wellington) for his critical review of the original Portuguese manuscript, for translating it into English and for reviewing the final draft.

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Received in 20.IV.2006; accepted in 30.X.2006.